

A Comparison of Nutritional Indices

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THIS study was conducted for the purpose of determining which of the three indices of nutrition—Baldwin-Wood Weight-Height-Age Tables, Pelidisi, or A-C-H—correlates most closely with an experienced doctor's estimate of nutritional status. The fact that there is so little agreement between the various indices of nutrition prompted the study. It consisted of the measurement of 1016 school children, eight to twelve years of age, in the schools of Ypsilanti, Michigan, and vicinity. There were 505 boys and 511 girls. Table I gives the age distribution of the children: the age was recorded as of the nearest birthday.

TABLE I

DISTRIBUTION OF AGE GROUPS OF 1016 SCHOOL CHILDREN USED IN THIS STUDY

Age	Boys	Girls	Total
8 years	80	86	166
9 years	95	102	197
10 years	103	124	227
11 years	114	100	214
12 years	113	99	212
Totals	505	511	1016

It is advisable to have in mind what we mean by the term "malnutrition" before proceeding with the problem. Manny explains the term very well when he says that it is not merely a matter of food, but that nutrition serves as an index of the results of the many strains and stresses that come from adenoids, enlarged and infected tonsils, defective eyesight, and other effects of native disability and unhygienic living.^{25 *}

Following is a description of the technique used in the four indices of nutrition:

1. The doctor's rating was recorded according to a modified Dunfermline scale, which consisted of four classifications, viz.:¹

a) Excellent—the nutrition of a healthy child of good social standing.

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*Indices refer to Bibliography at the end of this article.



b) Good—a child whose nutrition falls just short of the above standard.

c) Fair—one whose nutrition is on the borderline of serious impairment and who should have some nutritional supervision.

d) Poor—one whose nutrition is seriously impaired, and who needs constant medical attention.

Those children classified in groups *c* and *d* were considered as malnourished.

The factors considered in making the ratings according to this scale were general appearance of the child, color of the skin and the mucous membranes, subcutaneous tissue, musculature, facial expression, lustre of eyes, posture, and any other symptoms of normal or abnormal nutritional status. The ratings were unbiased by any other nutritional scale, as the physician did not know the weight or the height of the children. The only way in which the factor of weight entered into the rating by this scale was by the general proportion of weight to height and age. Dr. Glenadine Snow of the Michigan State Normal College, Ypsilanti, made all the examinations and recorded them according to the above scale. Since she is doing this type of work regularly and has had several years' experience in this field, her judgment is considered as accurate as that of any doctor or pediatrician whose services might have been obtained.

2. According to the Baldwin-Wood Weight-Height-Age Tables, any child whose weight was ten per cent or more under the average for his or her height and age was considered and recorded as malnourished.²⁹ The authors claim for these tables that they can safely be used as good standards of growth, since the children from whom the tables were compiled were healthy, had physical training, medical inspection, and careful remedial treatment. For the rating according to this scale the weight was taken without shoes, and in ordinary clothing without sweaters, coats or jackets (all the children were weighed on the same scales—a new set of balance scales). The height was taken without shoes, being careful to have the subject's heels, hips, shoulders, and back of head touching the measuring standard.

3. The "Pelidisi" consists of the formula,⁷

$$\frac{\sqrt[3]{10 \times \text{body wt. in grams}}}{\text{sitting height in centimeters}} = \text{Pelidisi}$$

with 95–100 being the ideal Pelidisi for a growing child who is well nourished. In this study a Pelidisi of 93 was considered as the minimum lower limit that a child could have and be considered as of having a satisfactory nutritional status; below this figure was recorded as malnourished. The apparatus which was used in obtaining the sitting height of the children consisted of a chair cut down so that the seat was just thirteen inches from the floor, and the front of the chair was twelve and

one-half inches from the back. To the back of the chair was fastened a meter stick. In taking the measurements for the sitting height care was taken to have the child sit erect, so that the sacrum was well against the back of the chair, and the shoulders and back of the head were against the measuring stick; a square was used against the measuring stick and the child's head to insure an accurate reading. Using a chair as low as this one prevented the muscles on the dorsum of the thighs touching the seat of the chair, so that the subject sat squarely on the tuberosities of the ischia. To follow out this technique uniformly it was necessary to place a block of wood under the feet of a few of the very smallest children. This method of measurement prevented variations of results as a result of the thigh muscles contracting. Undoubtedly the cause of the high percentage of malnutrition among children obtained by Baker and Blumenthal according to this method was due to the failure to take this precaution.¹ They had the subjects sit with the legs hanging over the edge of the chair so that the feet did not touch the floor. This would increase the sitting height which would result in a lower Pelidisi.

4. The A-C-H (Arms-Chest-Hips) index of nutritional status is fully explained in the pamphlet by Franzen and Palmer published by the American Child Health Association in 1934.²⁰ Briefly, it is as follows: all measurements were taken with sweaters and coats removed, upper arm laid bare, and the boys' pockets emptied. The instruments used in taking the measurements were a steel tape with a Gulick handle to insure uniform tension on all measurements, and large sliding wooden calipers, both graduated in tenths of centimeters. These instruments were purchased from the American Child Health Association, New York.

The measurements of the *arm* girth were taken with the steel tape. The child was instructed to "make a muscle" and the highest part of the biceps was marked with a crayon. Then the child was instructed to keep the arm in this position, but to relax the muscles and open the hand so that the finger tips loosely touched the shoulder: the measurement was then taken around the upper arm at the point marked by the crayon. Then another measurement was taken at the same place on the arm, but with the arm hanging loosely at the side. The sum of these two measurements was recorded on the score card.

The *chest* depth measurements were taken with the large sliding caliper according to the following procedure: the child stood naturally with his arms hanging at his side. The operator stood facing the child's left side and placed the caliper so that the base was at right angles to the lateral diameter of the chest, the movable branch of the caliper just beneath the inferior angle of the left scapula, and the fixed branch of the caliper just above the left nipple. Then as the child breathed naturally the readings were taken at both expiration and inspiration. The sum of these two readings was recorded and subtracted from the sum of the arm girth measurements: the difference was recorded on the score card.

The intertrochantric *hip* width was also taken with the sliding caliper: this measurement was taken facing the child who stood naturally with feet together and arms hanging at his sides. The measurement was recorded on the score card.

To determine the rating by this index of nutrition, the child is considered as malnourished if the difference between the sum of the chest measurements and the sum of the arm measurements is equal to or less than the minimum difference allowed for a child of this particular hip width, according to tables for boys and girls given in the pamphlet previously referred to.

This scale is intended for use on children from seven to twelve years of age, and the authors claim that it will select about ten per cent of a normal sampling of children.

The reason for using only those children from ages eight to twelve inclusive was that twelve years was the upper age limit for use of the A-C-H index, and it was found difficult to obtain authentic information from children younger than eight years of age. Table II gives a list of schools in which children were examined, the number of children examined (boys and girls), and the number and percentage malnourished according to the Dunfermline scale.

It will be noted that Prospect and Woodruff schools had the highest percentage of malnourished children—34.5 per cent and 28.8 per cent respectively. This was to be expected from the location of the schools and the social status of the majority of the families whose children attended these schools, the families being for the most part of the laboring class. Neither was it surprising to find the children from the Denton school having the lowest percentage of malnutrition—17.1 per cent, as this is a “rurban” community ideally located. In no case was the percentage of malnutrition as high among the girls as among the boys.

It will be noted in Chart I that in the case of the girls the lines representing the Dunfermline and the Baldwin-Wood scales run practically the same except for the eight-year age group, where the Baldwin-Wood tables select less than half as many as the physical examination (Dunfermline), as being malnourished.

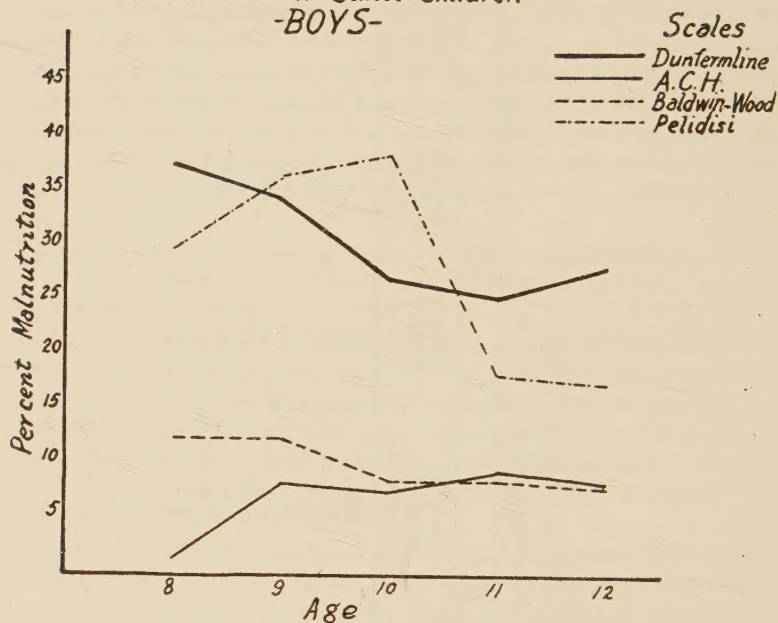
It also will be noted that the A-C-H index does not in this study select nearly as many cases of malnutrition as the authors claim for it—in this case selecting only 3.3 per cent. (See Table III.) In the case of the boys, the Pelidisi scale more nearly than the others approximates the percentages selected by the physical examination. According to the Dunfermline scale there seems to be less malnutrition in the eleven-year age group, for both boys and girls, than at any other period considered: this also is true of the Pelidisi except for age twelve in the case of boys, which is .7 per cent less than for age eleven.

Table III shows the percentage of malnutrition according to each of the four indices used—for boys and girls separately and for both sexes.

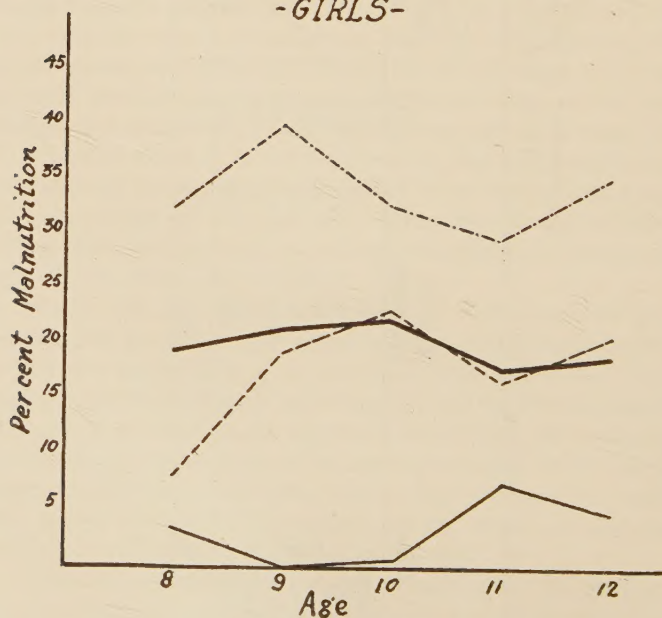
TABLE II
MALNUTRITION BY SCHOOLS AMONG 1016 SCHOOL CHILDREN
USED IN THIS STUDY. (DUNFERMLINE SCALE)

School	Total No. Examined	Boys	Girls	Boys		Girls		Boys and Girls Total Per Cent Mal- nourished
				Number Malnour- ished	Per Cent Malnour- ished	Number Malnour- ished	Per Cent Malnour- ished	
Denton	41	28	13	6	21.4	1	7.7	17.1
Central	277	127	150	33	26.0	28	18.7	22.0
St. Johns	62	24	38	7	29.2	7	19.2	22.6
Roosevelt	144	67	77	19	28.4	14	18.2	22.9
Lincoln	209	112	97	33	29.5	20	20.6	25.4
Woodruff	170	86	84	31	36.0	18	21.4	28.8
Prospect	113	61	52	23	37.7	16	30.8	34.5
Totals	1016	505	511	152	30.1	104	20.4	25.2

CHART I
Malnutrition in School Children
-BOYS-



-GIRLS-



It will be noted in the table, as well as in Chart I, that on the average the Pelidisi more nearly than any other scale approximates the results of the physician's rating, and that the A-C-H index falls down dismally in the number of cases of malnutrition which it detects—in fact, it did not select a single case among the 102 girls in the nine-year age group, while the doctor selected twenty-two or 21.6 per cent of this group as showing clinical evidence of malnutrition. This is the age group in which the Pelidisi selected the highest percentage of malnourished cases—40.2 per cent.

TABLE III

PERCENTAGE MALNUTRITION AS DETERMINED BY THE EXAMINATION OF 1016 SCHOOL CHILDREN BY FOUR DIFFERENT METHODS

Sex	Dunfermline			Baldwin-Wood			Pelidisi			A-C-H		
	Total	No Maln.	Per Cent Maln.	Total	No Maln.	Per Cent Maln.	Total	No Maln.	Per Cent Maln.	Total	No Maln.	Per Cent Maln.
Boys	505	152	30.1	505	50	9.9	505	140	27.7	505	38	7.5
Girls	511	104	20.4	511	94	18.4	511	175	34.2	511	17	3.3
Both Sexes	1016	256	25.2	1016	144	14.2	1016	315	31.0	1016	55	5.4

Table IV shows statistically that the difference in percentages between the Dunfermline and the Pelidisi scales has no significance; i.e., that this difference could be due merely to chance and therefore that the Pelidisi could be used as a substitute index for a physician's rating of nutritional status. However, the differences in percentages between the Baldwin-Wood tables and the doctor's rating, and between the A-C-H and the doctor's rating are statistically significant and are too great to be due to chance: therefore, the Baldwin-Wood tables and the A-C-H index can not be recommended as satisfactory substitute indices for the doctor's rating of nutritional status.

Table V gives a comparison between the number of children selected by the physician (Dunfermline scale) as malnourished and the number selected by each of the other scales. It will be noted from this table that the Pelidisi selects more of the cases, selected by the physician as malnourished, than either of the other scales, although it selects many more than either of the other scales of those not selected by the physician's rating. It also will be noted that the A-C-H index selects only twenty-four of the 256 cases judged by the doctor as being malnourished.

It is interesting to note that even though the coefficient of correlation is higher, for the total of 1016 children, between the Dunfermline and the Weight-Height-Age scales than between the Dunfermline and

TABLE IV

STANDARD ERROR OF DIFFERENCE IN PERCENTAGES OF MALNUTRITION AS DETERMINED BY THE EXAMINATION OF 1016 SCHOOL CHILDREN BY FOUR DIFFERENT METHODS, USING THE DUNFERMLINE SCALE AS THE CRITERION

Dunfermline			Baldwin-Wood			Difference Per Cent	Standard Error of Difference
Total Number Children	Number Children Maln.	Per Cent Maln.	Total Number Children	Number Children Maln.	Per Cent Maln.		
1016	256	25.2	1016	144	14.2	11.0*	± 1.75
Dunfermline			Pelidisi				
1016	256	25.2	1016	315	31.0	5.8	± 1.99
Dunfermline			A C H				
1016	256	25.2	1016	55	5.4	19.8*	± 1.53

*The difference in these percentages is more than three times the standard error and is therefore statistically significant.

TABLE V

CORRELATION OF DIFFERENT SCALES WITH DOCTOR'S RATING AND PERCENTAGE AGREEMENT BETWEEN DIFFERENT SCALES AND DOCTOR'S RATING ON 1016 SCHOOL CHILDREN

Scales	Malnour- ished by One Scale Only	Malnour- ished by Both Scales	Malnour- ished by Neither Scale	Coeffi- cient of Correla- tion	Prob- able Error	Per Cent Agreement in Malnour- ished Cases
Dunfermline Weight-Height-Age	168 56	88	704	.534	.015	28.2 (88÷312)
Dunfermline Pelidisi	114 173	142	587	.440	.017	33.1 (142÷429)
Dunfermline A C H	232 31	24	729	.124	.021	8.4 (24÷287)

either of the other scales, the percentage agreement on the malnourished cases is higher between the Dunfermline and the Pelidisi than between the Dunfermline and either of the other scales. It can be seen from this table also that there is practically no correlation between the A-C-H and the Dunfermline scales, and that the percentage agreement on the malnourished cases is also very low. The computation of the coefficient of correlation depends not only upon the small group classed as malnourished, but also upon the much larger group not classed as malnourished. Since this latter group is much larger in the Dunfermline scale and the Baldwin-Wood tables comparison than in the comparison of the Dunfermline Scale with the Pelidisi, it is not surprising that the coefficient

of correlation is higher in the former case. It would be possible to have two indices of nutrition which did not pick a single case of malnutrition, yet there would be 100 per cent agreement between the two indices on the cases not malnourished, and possibly almost perfect correlation, but neither index would be of worth in evaluating the nutritional status of children. Therefore, it is not the coefficient of correlation by which we should be guided in selecting a nutritional index, but the agreement on those cases selected as malnourished.

To give a better idea of the pathetic lack of agreement between the various nutritional indices Table VI is presented. It is astonishing to note that although of the 1016 children 466 were rated as malnourished by one or more scales, only 7 of this number were rated as malnourished by all of the four scales. An analysis of Table VI will reveal that the A-C-H scale is in a large measure responsible for such a great disagreement between all scales, since the other three scales agree on 75 cases as being malnourished.

TABLE VI

TOTAL NUMBER OF CHILDREN RATED AS MALNOURISHED BY ONE OR MORE SCALES ON 1016 SCHOOL CHILDREN, AND PERCENTAGE AGREEMENT OF SCALES

Malnour- ished by All Scales	Malnour- ished by All Scales Ex- cept A-C-H	Malnour- ished by Some Scale, not by All Scales	Total Mal- nourished by Some or All Scales	Malnour- ished by No Scale	Percentage Agreement of Scales
7	68	459	466	550	1.5% (7÷466)

The question may arise as to how the doctor classified those children selected by the other scales as malnourished. The following figures will answer this question:

I. *Baldwin-Wood Tables*.—144 selected as malnourished:

Of these 28, or 19 per cent were rated by the doctor as poor,
61, or 43 per cent were rated by the doctor as fair,
52, or 36 per cent were rated by the doctor as good,
and 3, or 2 per cent were rated by the doctor as excellent.

II. "*Pelidisi*."—315 selected as malnourished:

Of these 36, or 11.4 per cent were rated by the doctor as poor,
105, or 33.3 per cent were rated by the doctor as fair,
164, or 52.1 per cent were rated by the doctor as good,
and 10, or 3.2 per cent were rated by the doctor as excellent.

III. *A-C-H*.—55 selected as malnourished:

Of these 7, or 13 per cent were rated by the doctor as poor,
17, or 31 per cent were rated by the doctor as fair,
29, or 53 per cent were rated by the doctor as good,
and 2, or 3 per cent were rated by the doctor as excellent.

From these data it will be seen that from those cases selected as malnourished by each of the three indices, the percentage selected by the physician as malnourished is higher in the group selected by the Baldwin-Wood tables than in either the "Pelidisi" or the A-C-H.

As a result of the data collected in this study and the analysis thereof, the writer cannot agree with Franzen,^{18, 19, 20} Palmer, Mitchell, and coworkers that the new A-C-H index is a satisfactory index of nutritional status. This is apparent from the fact that this index selected only 24 of the 256 cases selected by an experienced pediatrician. There seems to be little choice between the "Pelidisi" and the Baldwin-Wood tables—the percentage agreement between the former and the physician's estimate of the malnourished cases being a little higher, while the coefficient of correlation between the latter and the doctor's estimate on the total number of cases (1016) is a little higher. (See Table V.) The doctor's rating was used as a criterion of the other nutritional indices, inasmuch as it is the consensus of opinion of nutritional workers that the experienced physician's estimate is the best-known method of determining the nutritional status of an individual.

This work may be criticized on the basis that the Dunfermline rating was made by the judgment of one physician only. It is the writer's opinion that the judgment of *one* physician, who has had a great amount of experience in judging the nutritional status of children, is to be preferred to the average judgment of several doctors, for the following reasons:

1. The judgment of *one* doctor is a rating which is very definite.
2. The judgments of several doctors introduce so many variables that it is difficult to come to a definite conclusion as to the nutritional status of an individual. A group of children examined by, let us say, five doctors, might be practically all classed as malnourished by some one of the five examiners. An interesting example of the wide discrepancies in judgment of examiners is given in the publication, "Physical Defects, the Pathway to Corrections,"²⁷ in reference to children recommended for tonsillectomy.

It will be interesting in connection with this work to consider briefly some of the factors which may influence the nutrition of children. Using the Dunfermline rating as the index of nutrition, the factors of race, occupation of father, number of children in the home, and the dwelling house congestion, will be considered to determine their influence, if any, on the nutritional status of the children.

In compiling Table VII for the race groupings and the malnutrition of children according to nationality, the nativity of the mother was used to insure uniform procedure. When the child did not know the principal European stock in the nationality of the parents, he was considered as American if his parents and grandparents were born in this country. Colored children are listed as a separate nationality. Eight nationalities

are listed, with the United States having almost half of the total number studied. To give an indication of the variety of nationalities under those not noted—there were fourteen additional nationalities included but the numbers in each were too small to consider separately. It will be noted that the highest incidence of malnutrition was among children of Irish stock, (31.1 per cent). Poland was lowest with only 10 per cent malnourished. The United States ranked in fifth position with 25.9 per cent malnourished. In this connection it is interesting to note that the average percentage of malnourished children of all nationalities was 25.2 per cent, or 256 children from the total of 1016 examined.

TABLE VII
MALNUTRITION BY RACE GROUPS AMONG 1016 SCHOOL CHILDREN
(DUNFERMLINE SCALE)

Nativity of Mother	Number Examined	Number Malnourished	Percentage Malnourished
Ireland	45	14	31.1
France	46	13	28.3
Colored	30	8	26.7
Germany	138	36	26.1
United States	474	123	25.9
England	166	39	23.5
Scotland	22	3	13.6
Poland	30	3	10.0
All Others (Combined)	65	17	26.2
Totals	1016	256	25.2

Malnutrition as determined by the occupation of the father is presented in Table VIII. In determining the classes, two classifications were used, viz., the non-laboring class consisting of professional and mercantile occupations, and the laboring class consisting of skilled and unskilled laborers. From this study it was determined that the percentage of malnourished children from the non-laboring homes was 20.7 per cent as

TABLE VIII
MALNUTRITION AMONG 1016 SCHOOL CHILDREN AS DETERMINED BY OCCUPATION OF FATHER (DUNFERMLINE SCALE)

Class	Total Number of Children	Number Malnourished	Per Cent Malnourished	Difference Per Cent	Standard Error of Difference
Non-Laboring (Professional and Mercantile)	213	44	20.7	5.7*	3.18
Laboring (Skilled and Unskilled)	803	212	26.4		
Totals	1016	256	25.2		

*The difference in these percentages is less than three times the standard error and is therefore statistically insignificant.

compared with 26.4 per cent from the laboring homes: although this seems to be a considerable difference in percentage, it is not statistically significant as evidenced by the standard error of difference.^{14, 34}

We often hear it said that a child coming from a home where there are no other children has a fair chance of being malnourished, even in the midst of plenty, as he is often pampered and spoiled so that he does not eat properly. In this connection it is interesting to note the information given in Table IX.

TABLE IX
MALNUTRITION AMONG 1016 SCHOOL CHILDREN ACCORDING TO NUMBER OF
CHILDREN IN HOME (DUNFERMLINE SCALE)

Number of Children in Home	Total Number of Children	Number Malnourished	Percentage Malnourished	Difference Per Cent	Standard Error of Difference
One	105*	21	20.0	5.8†	4.16
More than one	911	235	25.8		
Totals	1016	256	25.2		

*Only five of these were in non-laboring class.

†The difference in these percentages is less than three times the standard error and is therefore statistically insignificant.

There were two classes of homes used for this study, viz., one of one child only in the home, and the other of homes having more than one child. The percentage of malnourished children in the former class was 20 per cent, while that for the latter class was 25.8 per cent. Although there is a difference of 5.8 per cent in favor of the homes having only one child, this difference is not statistically significant as evidenced by the standard error of difference.

Another factor which may influence the nutritional status of children is the dwelling house congestion, or the number of individuals per room of the home. To gain some information relative to this factor three classes were used in compiling Table X, representing different degrees of housing congestion:

- a) Children from homes having less than one person per room.
- b) Children from homes having one person per room.
- c) Children from homes having more than one person per room.

TABLE X
DWELLING HOUSE CONGESTION AS A FACTOR IN MALNUTRITION OF 1016 SCHOOL
CHILDREN (DUNFERMLINE SCALE)

Degree of Housing Congestion	Number of Children	Number Malnourished	Percentage Malnourished
a) Less than one person per room	645	153	23.7
b) One person per room	133	36	27.1
c) More than one person per room	238	67	28.2
Totals	1016	256	25.2

From this study it was found that the percentage of malnourished children from class *a* was 23.7 per cent; from class *b* 27.1 per cent, and from class *c* 28.2 per cent. This would seem to indicate that nutrition is influenced by the degree of congestion in the dwelling, although these differences in percentages are not statistically significant.

CONCLUSION

This study seems to indicate the following:

1. There is little agreement between the various indices of nutrition used in this study.

2. Sex is a factor which has statistical significance as influencing nutrition, as evidenced by the doctor's rating of 20.4 per cent of the girls and 30.1 per cent of the boys as malnourished.

3. *a*) Considering both sexes as a group: neither the A-C-H index nor the Baldwin-Wood Weight-Height-Age Tables seems to select enough cases of malnutrition according to the doctor's rating. According to the percentage agreement with the doctor's rating of the cases of malnutrition, the choice of the scales should be—first, Pelidisi; second, Baldwin-Wood Tables, and third, the A-C-H index.

b) Considering the sexes separately: by referring to Chart I, it will be seen that in the case of the girls the Baldwin-Wood Table agrees very closely with the doctor's rating, while in the case of the boys the Pelidisi more nearly approximates the doctor's rating. The A-C-H has little agreement in either sex with the doctor's rating, but in the case of the boys it agrees quite closely with the Baldwin-Wood Table. The A-C-H seems better suited for use on boys than on girls.

Comments.—

1. Since there is very little difference between the Pelidisi and the Baldwin-Wood Tables in agreement with a physician's rating of the nutritional status of children, it may be advisable and more practical to use the Baldwin-Wood Tables on account of the complexity of the Pelidisi index.

2. Incidental to this study it was found that the factors of race, occupation of father, number of children in the family, and the degree of congestion in the dwelling, had no statistical significance as influencing the nutritional status of children. However, there seemed to be a tendency toward more malnutrition in the poorer homes, having several children in the family, and where the living quarters were congested.

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